NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE

8.0 - 1 0.0 3 7
CR-162448

"Made available under NASA sponsorship in the interest of early and wide dissemination of Earth Resources Survey Program information and without liability for any use made thereof."

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada
Canada Centre for Remote Sensing
Centre Canadien de Télédétection

(E80-10037) HCMM/SOIL MOISTURE EXPERIMENT Progress Report (Canada Centre for Remote Sensing, Ottawa) 12 p HC A02/MF A01 CSCL 08M
N80-15531
Unclas
G3/43 00037

HCMM/SOIL MOISTURE EXPERIMENT
Investigation Number: HCM-054

Josef Cihlar
Applications Division

RECEIVED
NOV 30 1979
SIS/902.6
HCMM 054
TYPE II

PROGRESS REPORT
31 August, 1979

1. Introduction

The experimental plan developed for the HCMM/Soil Moisture Experiment (HCMM Project 054) was based upon the collection of satellite, airborne, and ground data during the 1978 growing season and their subsequent analysis. Following the launch of the HCMM satellite on 26 April 1978, two airborne missions were planned and subsequently flown on 21 June 1978 and 5 August 1978 near Brooks, Alberta. Each mission consisted of an early afternoon and after midnight overpass of selected experimental plots and agricultural fields. Thermal infrared scanner data were collected during both overflights, and colour infrared (CIR) photographic transparencies were also obtained for the afternoon flight. Similar missions were undertaken on 19 July 1979 and 6 August 1979 over different sites in the same general area. During the following autumn and winter, ground and airborne data were processed, reduced and partly analyzed. None of the 1979 data were processed prior to 31 August 1979.

2. Techniques

2.1 Satellite data

Upon delivery, HCMM satellite images were assessed to determine if the data were of sufficient quality to be analyzed in detail. Particular attention was paid to cloud cover and to indications of system noise. The images were then catalogued by geographic location and date. An overview of available images and their quality was maintained for each month over the area.

2.2 Airborne data

The 1978 airborne thermal infrared images were obtained with a Daedalus scanner at two resolutions, 19m for farm fields and 1.5m for experimental irrigation plots. Following the mission, analogue and density sliced (8 levels) transparencies were produced from data recorded on a Mincom tape. The latter image products were used during a preliminary analysis. Subsequently, relevant portions of scanner data were digitized (256 levels, 1024 pixels/scan line). The CIR photographs were processed as transparencies on which the ground sample locations were identified using known landmarks and notes produced by the field parties. The day and night digitized thermal data were then separately displayed on the CCRS Image Analysis System, and signal values over sampled sites extracted using a cursor option on the system. Reference temperature calibration data were obtained for each flightline in the same manner. The digital data were then converted into apparent temperatures, and a value of the diurnal (day minus night) temperature difference was calculated for each site.

2.3 Ground data

Fifteen farm fields with different crops (irrigated corn, alfalfa, fall rye, potatoes, flax, and peas; non-irrigated wheat, native range, and summerfallow) and five experimental plots (potatoes, carrots, cabbage, mustard, faba beans; each plot contained three irrigation water treatments and four replicates) were chosen for the study. During the day of each airborne mission, one soil profile per experimental plot and up to six profiles per farm field were sampled. From each profile, four samples at 30 cm increments were taken. Water content of each sample was determined using the gravimetric procedure. For the same sites and depth increments, field capacity (0.33 bar) and permanent wilting point (15 bar) values were obtained from soil texture and available data (both published and unpublished). From these data and using

root depths obtained from the Alberta Agriculture irrigation scheduling program, the amounts of plant-available water (in percent of the above-permanent-wilting-point storage volume) were calculated. In addition, plant canopy observations and ground photographs were taken during or close to the dates of aircraft missions.

3. Accomplishments

No specific HCMM data analysis was undertaken prior to 31 August 1979 (see Section 4).

4. Significant Results

An ongoing review of the HCMM satellite data received so far has not revealed image triplets of a quality which would allow detailed digital analysis to be carried out. Table 1 shows cloud cover statistics (based on visually estimated percentage cloud cover for each overpass) for the period May to December 1979, and all data received over western North America. The daytime cloud cover fluctuated around 60%. Daytime thermal IR images also often showed reduced apparent temperatures over areas where no clouds were evident on the visible band images, presumably as a result of thin cirrus clouds. Nighttime cloud cover monthly means were always lower than daytime values (Table 1); some excellent nighttime thermal images were received over Rocky Mountains, particularly in northwestern U.S.A.

From data received so far for August 1978, two partly cloudfree images cover portions of south Alberta. Pending the reception of additional less cloudy data, these images could be used for a more detailed analysis. A search has been requested to ascertain whether better August and June coverage exists over the area. Until the search is completed, no digital HCMM data will be ordered. However, the capability to read HCMM format tapes has been ascertained.

Since during a preliminary work carried out in 1976 and subsequently the variable plant cover was found to have a significant effect on detecting soil moisture/plant stress (Cihlar, 1980), the initial analysis of airborne measurements concentrated on the August 1978 data. A plot of apparent temperature ranges (obtained from density sliced day-time imagery) versus root zone available water (Figure 1) showed that non-irrigated fields had considerably higher day-time apparent temperatures than irrigated fields. This might be partly due to crop type but an inspection of CIR photos suggests that the increase was primarily due to a lower proportion of green plant cover compared to bare ground (and brown cover for rangeland). Seven corn fields shown in Figure 1 were analyzed in detail using the procedure described in Section 2.2. The results (Figure 2) show essentially the same trend as in Figure 1, thus confirming the validity of the irrigated/non-irrigated field separation.

The effect of reduced green cover is also evident in Figure 3 which shows results for five crops planted in the experimental plots. While three crops with similar coverage (cabbage, mustard, potatoes) exhibited a similar regression relationship, the low cover carrot plot had much higher temperature differentials. (The reason for reduced faba beans differentials has not been ascertained to date).

Preliminary results shown in Figure 1 and 3 as well as others (Cihlar, 1980) strongly support the hypothesis that the proportion of green plant cover or same combination of cover and biomass have the first-order effect on the diurnal temperature difference measured over crop canopies, while moisture stress is at best a second-order effect. Attempts to use CIR film density measurements as surrogates of green plant cover for improving soil water content prediction (Cihlar, 1980; McKenzie *et al*, 1979) have not been successful so far.

Should the above hypothesis prove correct, it will have the following important implications on soil water estimation in agricultural areas:

(i) Spatial resolution must be sufficiently detailed to avoid mixing crop types with different green plant coverages which could introduce large uncertainties as to the reason for increased temperature (soil water, plant cover, or various combinations of the two);

(ii) For pure (one cover type) pixels, plant coverage, biomass or both must be determined. Knowledge of these quantities would allow identifying pixels with full canopy cover (background effect negligible) for which water stress detection would be free from variable canopy effects. To determine soil water status for partial canopies the effect of canopy cover on the temperature difference measured for these pixels would have to be accounted for first.

5. Publications

The following relevant publications have been prepared since the HCMM launch.

Cihlar, J., T. Sommerfeldt, and B. Paterson. 1979. Soil Water Content Estimation in Fallow Fields From Airborne Thermal Scanner Measurements. Canadian Journal of Remote Sensing, Vol. 5, No. 1: 18-32.

McKenzie, R.C., N. Clark, and J. Cihlar. 1979. Use of Thermal Infrared and Colour Infrared Imagery to Detect Crop Moisture Stress. Interim Report, March 1979.

Cihlar, J. 1980. Soil Water and Plant Canopy Effects on Remotely Measured Surface Temperatures. To be submitted for publication.

6. Problems, Data Quality and Delivery

The major problem has been a lack of good quality HCMM satellite image triplets over the study area. This is in part due to cloud cover problems and in part due to data delivery.

Because of the persistent cloud cover problems, it may be necessary to use partially cloudy scenes which had clear sky over the areas of primary interest. These scenes are impossible to identify without physically inspecting all partly cloudy images. Therefore, the request for digital data must be delayed until -

(i) good quality image triplets including low cloud cover are received in regular data shipments; or

(ii) all recorded data are inspected and the best available image triplets are identified.

NASA/GSFC assistance has been requested on item (ii).

7. Recommendations

None.

Table 1. Cloud cover statistics for HCMM data received for Western North America.

Centre frame latitudes 44° to 50°
Centre frame longitudes 102° to 128°

Time of Overpass	Cloud Cover	Month of 1978 May	June	July	August	September	October	November	December
Day	Mean	74	58	62	55	67	58	75	46
	Standard Deviation	18	18	16	27	16	29	13	26
Night	Mean	61	33	27	36	57	48	57	25
	Standard Deviation	25	22	22	27	24	29	36	0

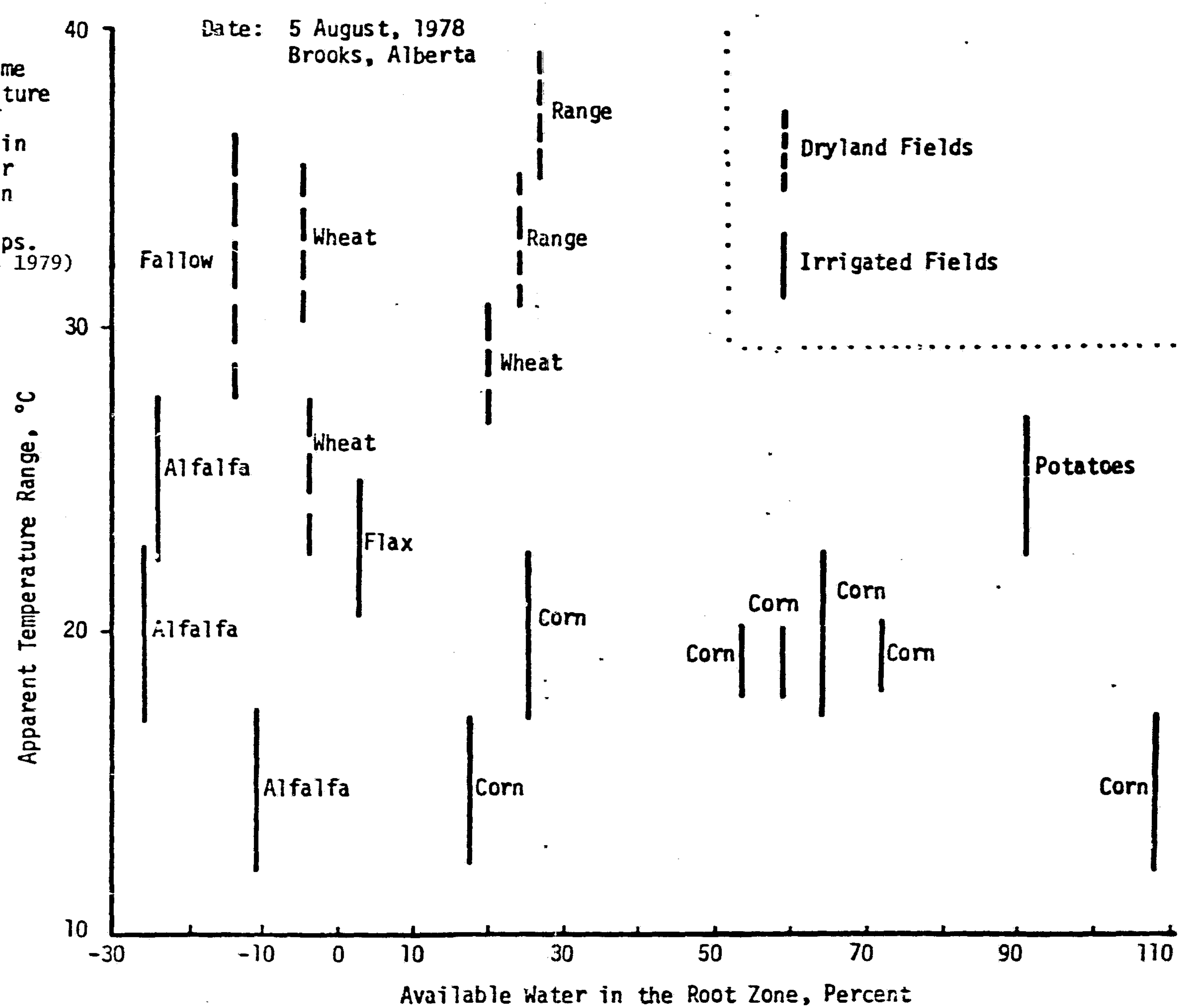

FIGURE 1. Daytime apparent temperature as a function of available water in the root zone for irrigated and non irrigated fields with various crops.
(From McKenzie *et al* 1979)

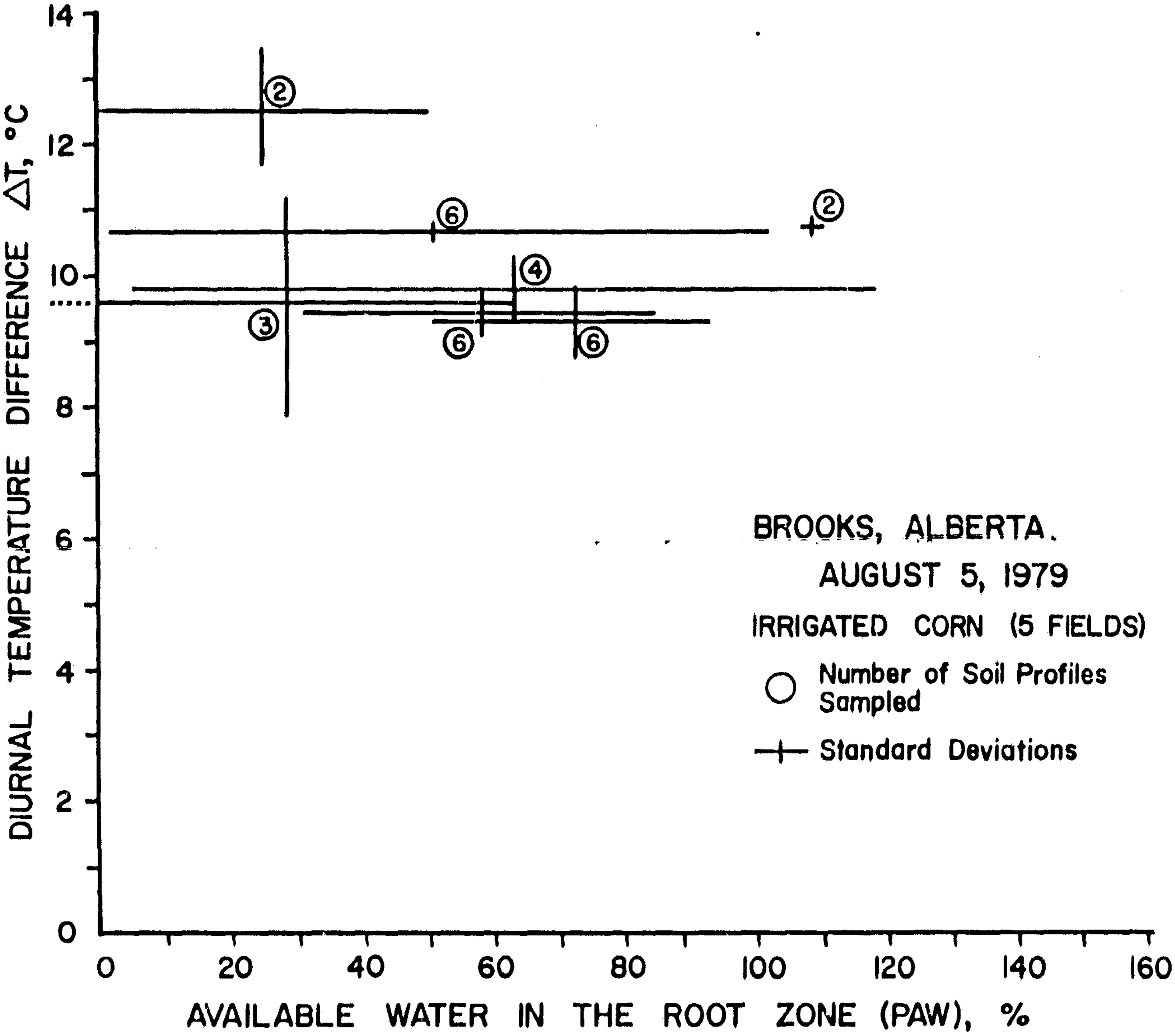

FIGURE 2. Diurnal apparent temperature difference as a function of root zone available water for irrigated corn fields.

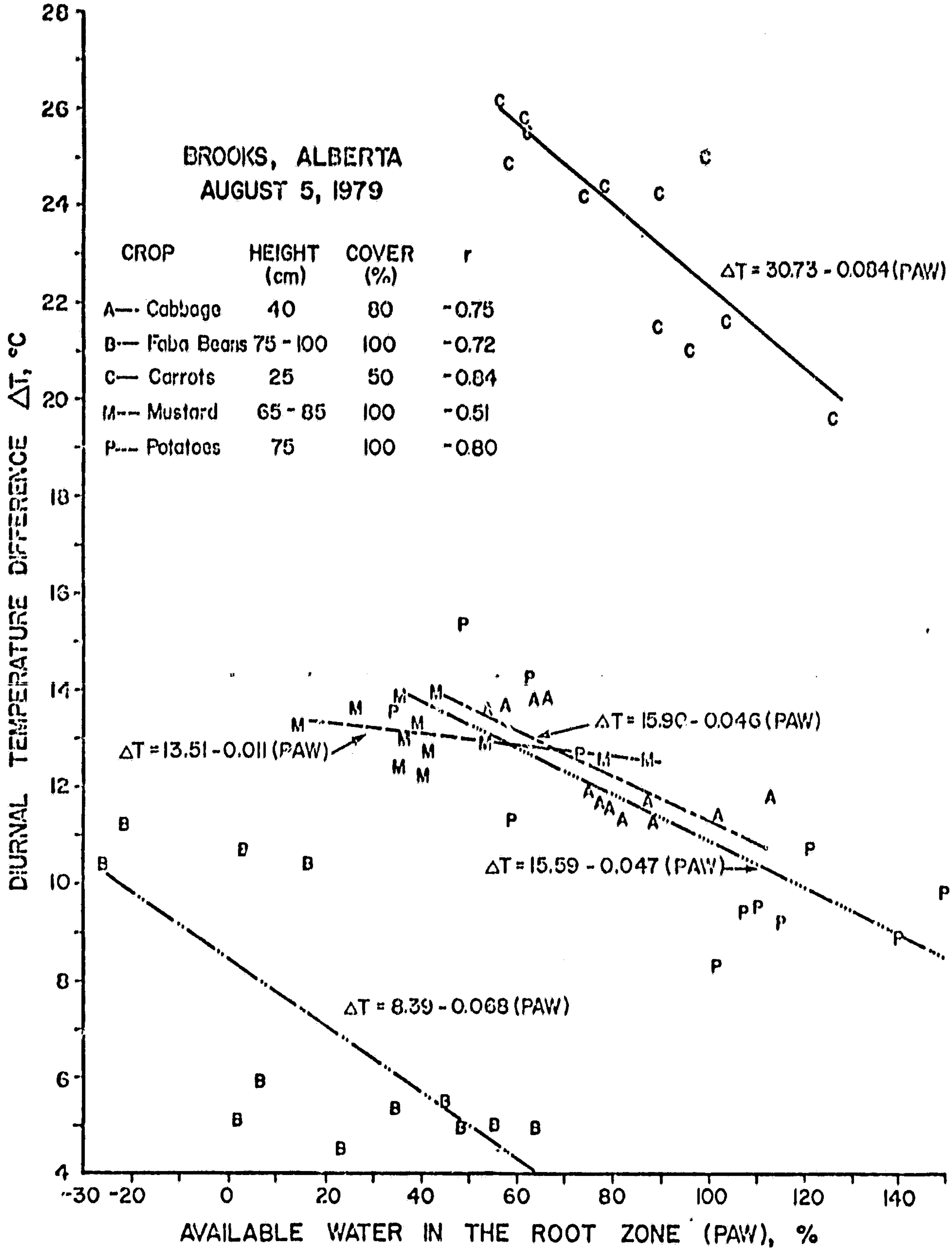

FIGURE 3. Diurnal apparent temperature difference as a function of root-zone available water for five crops grown on irrigated experimental plots.